Development of an Autonomous Family Vehicle using a Scenario-Based Design Approach

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Content

Summary

One major challenge when designing autonomous vehicles is to enable independent and safe use by a wide range of users, including those who are reliant on an accompanying person when using a conventional car. In this paper, we present the use of a scenario-based design approach for the development of a novel autonomous vehicle, which is intended for the use within a multigenerational family. With the help of hypothetical scenarios that describe the use of a driverless vehicle by different user types, we concretize requirements that were previously formulated at a higher level of abstraction. Moreover, the presentation of proposed solutions in concrete scenarios helps to identify weaknesses of the intended concepts and challenges that arise from the independent use of autonomous vehicles by certain user groups. The resulting requirements, which significantly depend on assumptions regarding potential user restrictions, have a far-reaching influence on the entire vehicle design.

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1 Introduction

Automatically driving vehicles promise more autonomy to people who are not able to operate a conventional car due to physical or mental restrictions [1]. Nowadays, these people are often reliant on another person for individual transport. Usually, an assisting person drives the car and performs supporting tasks depending on the needs and abilities of the accompanied person. For example, parents ensure the safe exit of their child or assist an elderly family member when getting in and out of the vehicle. Therefore, a driverless vehicle that is intended for the independent use by minors and elderlies with age-related restrictions needs to compensate for the absence of an accompanying person.

Within the framework of the project UNICAR*agil*, presented in [2], an autonomous family vehicle is to be developed and realized on the same modular platform as three other driverless vehicles. The autonomous family vehicle, named autoELF, is intended for private ownership within a family and supposed to offer individual mobility even to minors and motor-impaired elderlies. In a previous publication, we presented an initial requirement analysis based on a theoretical analysis of accompanied rides in a conventional vehicle [3]. We created descriptions of the current situation of potential users of an autonomous family vehicle when using a conventional car with the help of a required accompanying person. The abstract functional requirements that were derived from this approach highly depend on the abilities of the person being accompanied. For example, the vehicle needs to ensure a safe and secure use by minors and provide a barrier-free access to enable elderly people with motor-impairments to enter the compartment independently. However, the activities of an accompanying person are rarely directly convertible into technical solutions. Therefore, is not possible to use this previous approach for the concretization of all requirements, which is necessary for the planned realization of the autonomous family vehicle. In addition, it has not yet been possible to validate the envisaged solutions. At the same time, our previous approach does not support the identification and consideration of problematic scenarios that can occur when an automatically driving vehicle is used independently by certain user groups. To date, we are not aware of any vehicle concept which comprehensively shows how the absence of a previously required accompanying person can be compensated.

In this contribution, we describe the development of an autonomous family vehicle by using a set of scenarios that describe the hypothetical use of the planned autonomous family vehicle by three contrasting fictive users. In Section 2, we outline the differentiation of the intended use case of a driverless vehicle from previous concepts and describe related research. After an introduction to the scenario-based design method in Section 3, an overview of the approach adopted by us is provided in Section 4. The definition of three fictive users, who are intended to represent contrasting user groups, is presented in Section 5. First design indications that could be derived from the created scenarios are presented in Section 6. Afterwards, a discussion and an outlook on further developments using the presented approach are given in Section 7.

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2 Initial Situation

Reasons why people choose a private car as their form of transport, even if they are not able to drive by themselves, can be manifold (e.g. time saving, comfort)[4]. Despite the evident benefits of automated vehicles for those who cannot use a conventional car by themselves, none of the concepts of driverless vehicles known to us directly addresses the use case of accompanied trips in today’s private vehicles. For instance, a lot of driverless vehicle concepts that are designed for individual transportation offer relatively sporty entries and seating positions. Examples are the EVE, presented by NIO [5], the SYMBIOZ Concept, shown by Renault [6], the F015 presented by Daimler [7], the Lagonda Vision Concept, shown by Aston Martin [8], or the AI:CON, presented by AUDI [9]. However, it is difficult for a person with motor disabilities, which are one of the major factors that hinder elderly to drive [10], to enter these vehicles’ compartments without human support. Most driverless vehicles that provide a barrier-free access and further functions for a barrier-free use are shuttle vehicles for a public transportation system. Examples are the driverless shuttle shown by Navya [11], the EZ-GO Concept presented by Renault [12], a driverless shuttle presented by Toyota [13], or the Accessible Olli presented by IBM [14], which is intended to be an accessible shuttle bus. Waymo included several design elements to provide accessibility for elderly or blind people [1]. However, Waymo has not shown a holistic concept for the independent use of driverless vehicles by passengers with multiple, age-typical restrictions, who would otherwise be dependent on an accompanying person when using a conventional car. Teague presented a driverless bus concept to replace today's school buses and to compensate for the absence of a bus driver by providing monitoring functions [15]. However, these—in part still rudimentary—concepts are not intended as a replacement for today’s individual transport by an accompanying person in a family private vehicle. Moreover, none of the concepts known to us presented a complete concept to ensure a safe use by minors without the presence of an adult who can monitor and intervene if necessary. Furthermore, we are not aware of publications that transparently present the entire consequences for the development of a driverless vehicle concept when persons as minors or elderlies are considered as independent users of a private, driverless vehicle. Accordingly, none of the driverless concepts we are aware of meets the requirements for an autonomous family vehicle as presented in [3].

At the same time, there are already several publications that have examined the acceptance and expectations of automated vehicles. For example, Tremoulet et al. [16] describe what parents expect from a driverless vehicle in order to let their children travel on their own. In [17], Nordhoff et al. investigate the acceptance of a driverless shuttle using a real test vehicle. Further examples for publications that examine user acceptance of driverless vehicles can be found in [18] or [19]. Although these previous publications provide numerous requirements for an autonomous vehicle from a user’s perspective, no investigation known to us addresses the particular use case of the autonomous family vehicle we are developing.

All in all, we are facing many novel, partly still uncovered challenges in the development of a privately owned autonomous vehicle that can accomplish everyday trips

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which previously required an accompanying person within a multigenerational family. Even though there are already many approaches, for example for the accessibility of vehicles, we are not aware of an entire vehicle concept that could be used as a model for the use case we consider. It is therefore a great challenge to cast existing, and in some cases novel, solutions into a product that meets the diverse requirements on a completely autonomously acting vehicle that can be used independently by all members of multi-generation family. At the same time, it is important to identify potential problems resulting from the independent use of a vehicle by certain user groups in advance.

3 Scenario-Based Design in the Development of New Products

In the context of design-processes, scenarios are narrative stories that describe a sequence of actions and events that lead to an outcome. A scenario consists of at least one actor and a setting [20]. In the development of human-computer interfaces, scenarios are used to determine requirements for a new product as described, for example, by Caroll and Rosson [21], as well as by Cooper [22]. Accordingly, scenarios that describe the current practice and actual problems are considered and an initial product design is derived from the results of an examination of these scenarios. Subsequently, scenarios that describe the use of the new product are analyzed for claims. Afterwards, the new product is iterated taking into account the findings from the previously analyzed scenarios [21]. Anggreeni and van der Voort suggest a framework for the use of scenario-based design in the development of tangible products and make a distinction between six kinds of scenarios [23]: After the identification of potential stakeholders and their stories, explorative scenarios are created. During the requirements gathering and the design process, actual practice scenarios, which describe the actual situation, and future practice scenarios, which represent the first design ideas, are considered. Moreover, interaction scenarios, which become increasingly concrete during an iterative process, and possible problem scenarios, which describe critical situations that can occur during the use of the intended product, are taken into account. By the use of validation scenarios, the planned product can be tested for the desired properties with the help of prototypes.

Potential users, who are the actors in usage scenarios, can be represented by personas, for which the use in scenarios is described by Nielsen [24]. Personas – as defined by Cooper [22] – are fictive characters that represent a group of potential users. Personas are characterized by different properties, such as their intentions, motivations or skills. Different sources can be employed to derive the information on which personas are based (e.g., empirical studies, interviews with users or experts). Advantages of a scenario-based design are described by Go and Carroll in [25]. For instance, scenarios are not only easy to generate, they also help to identify potential problems with the use of a product at an early stage of development, offer an opportunity to reflect on concepts under consideration, and provide a tool for brainstorming. A major advantage of scenarios is the comprehensibility for all kinds of stakeholders. This includes developers from different disciplines to whom a common basis for discussion is offered. Furthermore, it is possible to involve potential users, who have no

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technical expertise, by the help of hypothetical scenarios in the development process. A possible risk in using hypothetical scenarios is that the scenarios presented by developers are not realistic. Hence, the underlying assumptions, which lead to concrete scenarios, should be critically examined. At the same time, there is a risk that fictive users may not represent the intended user groups of a product. For successful product development, it is therefore important that the users shown in the scenarios are based on reliable sources [26]. Furthermore, acceptance among engineers might be insufficient, as the presentation of concrete personas and scenarios may have an unscientific appearance [26].

A practical example for the use of fictive personas in the development of an autonomous vehicle can be found in [27]. The publication presents the development of the interface of a public driverless vehicle using several personas who are hypothetical passengers of the vehicle. Moreover, in [28] the development of interaction elements in a future vehicle's interior by the help of three personas is described. These three personas are intended to represent key user groups.

4 Applied Approach

In the course of previous work, we have already constructed scenarios that describe the current situation of potential users of an autonomous family vehicle in a conventional car [3]. From that description, we derived first requirements for the new vehicle concept. Based on these requirements, we developed initial approaches for the realization of the vehicle. Subsequently, we started to develop scenarios that describe the use of the planned vehicle. Therefore, we created a description of three user types that were already assumed in our previous work: a minor, a middle-aged person, and an elderly person. Based on these three user types, we developed an initial set of future practice scenarios, which can be iterated to form the basis for interaction scenarios and possible problem scenarios in the course of further development.

For a structured creation of scenarios, the hypothetical regular use of the vehicle by the three considered user types was divided into four chronological phases. The first phase, the trip planning, includes all activities for the preparation and organization of a trip using the autonomous family vehicle. The second phase, the entry, covers all activities between the arrival of the vehicle at a starting point and its departure. The third phase, the ride, includes all activities during the actual ride. The fourth phase, the exit, begins with the vehicle's arrival at the destination and ends with its subsequent departure. Within each phase of use, different variants were possible, depending on the assumptions that were made previously. In addition, we included potential disturbing factors. These could be, for example, vehicle faults, disturbances in the infrastructure, or acute health problems of the transported person. A schematic illustration of our chosen approach for designing an autonomous family vehicle is shown in Fig.1.

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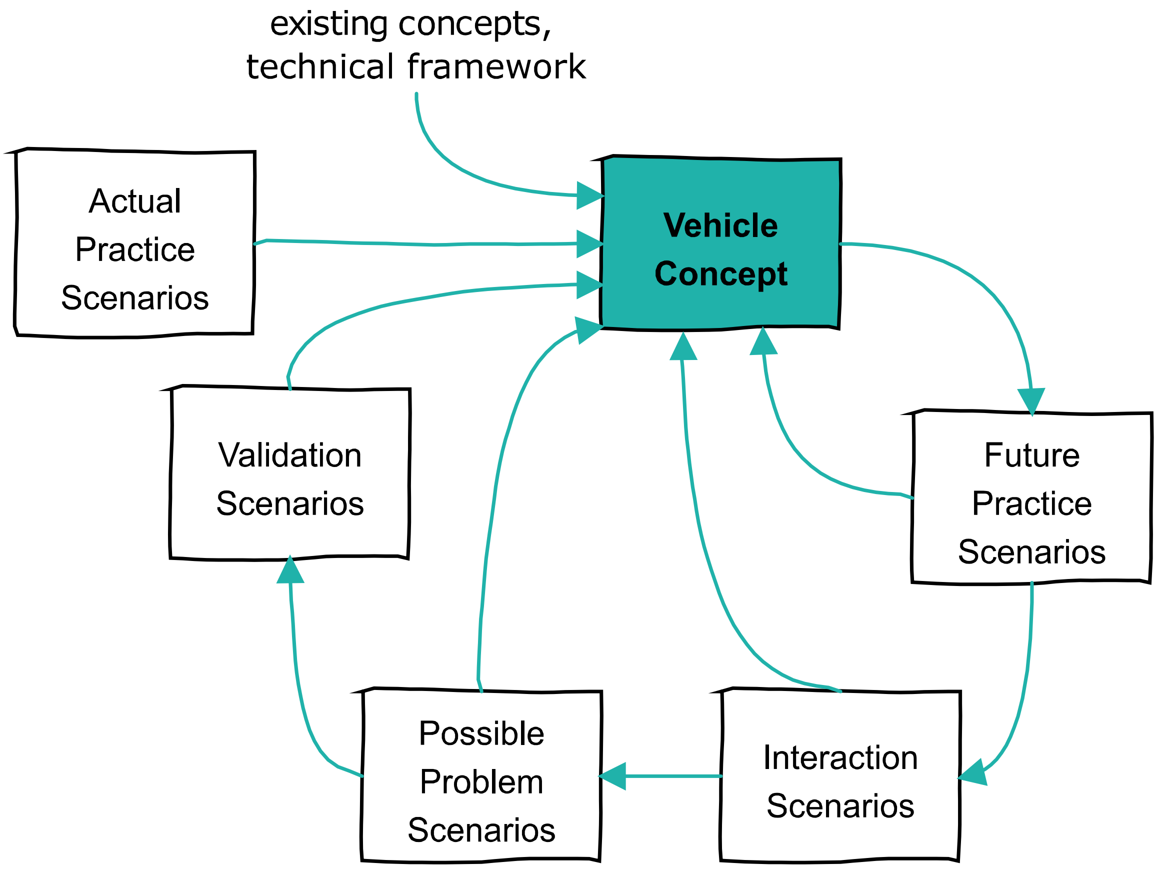

Fig. 1 Iterative development of different scenario types for the conception of an autonomous family vehicle.

By using three fictive users, different types of future practice scenarios were created as mentioned above. Requirements that were derived from actual practice scenarios (cf. [3]) formed the basis for these future practice scenarios. Furthermore, already existing proposals for the implementation of requirements and the results of a survey conducted at the beginning of the project UNICAR*agil* [29] were taken into account. In some cases, we had to distinguish between a conceptual solution and the solution that is planned for the prototypical realization of an autonomous family vehicle within the framework conditions set by the project UNICAR*agil*. When selecting a way of implementation, various aspects like technical feasibility in a private vehicle, safety aspects, and economic feasibility were taken into account. In addition, we tried to find solutions that are suitable for all user types in order to create an efficient overall design and to avoid parallel structures. Most concepts presented in the scenarios were iterated several times with the involvement of different developers. Especially for those scenarios that were regarded as the most critical, such as the independent entry of an elderly person with motor impairments, additional iterations were run through. This process has not been completed, yet. Furthermore, scenarios that are not covered by our initial combinations were gathered as a basis for future elaborations.

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Fig. 2 Seating buck with underfloor lift for barrier-free entry (Photograph published in 2020 on the social media channels of the project UNICAR*agil*).

For the description, discussion, and initial evaluation of the scenarios, various tools were used: In addition to textual descriptions and sketches, we utilized a seating buck (Fig. 2), virtual human models (Fig. 4), UML-charts [30], experimental hardware setups (Fig. 5), and prototypically realized user interfaces (Fig. 6).

5 Definition of User Types

Within the consideration of actual practice scenarios (cf. [3]) and the creation of an initial set of future practice scenarios, three aforementioned types of users were considered: a minor, named Johnny Doe, a middle-aged person, named John Doe, and an elderly person, named Jane Doe. The minor Johnny and the elderly Jane were assumed as non-driving who need to be accompanied when using a conventional car, whereas the middle-aged John was assumed as roadworthy and to be able to accompany others. It was assumed that Johnny and Jane are both family members of John, who drives them usually in their car. Therefore, John does not only benefit from using the autonomous family vehicle as a passenger, he also does not need to accompany his non-driving family members anymore if the family vehicle operates autonomously.

The three users are described narratively in the following three sections. Within a first literature search, we aimed at finding common features for the group of minors, for those who drive their non-driving family members by car, and for the elderly who are

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not able to drive a car. We mainly characterized the non-driving users by age-typical properties that hinder them when using a conventional car or that might be relevant when using an automatically driving vehicle. These properties are mainly restrictions in their abilities, which are personal prerequisites for performing an activity [31], and in the case of the minor Johnny, also restrictions in his permissions. Additionally, a short hypothetical description of the users' actual situation was given to provide a brief description of potential stakeholder stories, which can help to understand the motivation for the considered vehicle. Furthermore, we assumed that the three personas live in Germany. However, we expect that the personas can be adapted to other regions. The personas were described as generic as possible; details were only defined as specific as necessary at this early stage of development. In case of the minor Johnny, an age was explicitly defined since a direct connection between the listed characteristics and the age occurred during the research work. Emotions of the personas were not explicitly considered at this stage of development. However, it is planned to provide further details of the personas described below at a later stage of development.

5.1 Johnny Doe

Johnny is 12 years old. He usually rides a bicycle or scooter to school, but – like many other pupils [32] – he is sometimes taken to school by a parent with his family's car when the weather is bad. For most additional rides, for example to music lessons and to the sports club, Johnny is driven with the family's car, because his parents consider the distance too far for a bicycle ride. In addition, public transport is not always available to him. Just like many of his peers, he enjoys the comfort of being chauffeured [33]. As a pedestrian or cyclist, he is more at risk than adults since he does not have the attention and concentration of an adult [34]. Especially in the evening, he is accompanied by his parents by car, because like most parents [32], they are worried about the danger from strangers. Furthermore, Johnny's parents want to know where he is when he is neither at home nor at school. Therefore, Johnny has to ask his parents for permission when he wants to leave his home. However, Johnny, like most teenagers [33], is going to be allowed to move independently in more public areas as he grows older.

5.2 John Doe

John is a middle-aged person who has no specific restrictions. Therefore, he drives his relatives who cannot use a conventional car independently. In addition to the driving task, John also undertakes other activities to enable the accompanied persons to use the family car safely (cf. [3]). His work can lead to time constraints, as accompanying all non-driving family members can be very time consuming. Furthermore, there can be time conflicts, as John's working hours are not totally flexible, nor are his family members' appointments. In order to save time, he, as many others in his situation [32], tries to combine the rides for the purpose of accompanying his family members with other rides. For a driverless vehicle that can be used by his son on his own, John Doe wants the option to communicate with his son in an emergency, the option to view the vehicle's status and location, and the option to prohibit certain destinations [16].

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Fig. 3 Illustration of the described personas Johnny Doe, John Doe, and Jane Doe.

5.3 Jane Doe

Jane is an elderly woman who cannot use a car independently due to age-related restrictions. The main factors why Jane stopped driving a car are motor, perceptive, and sensory restrictions, which are common problems for elderly drivers [10], [35]. Jane suffers from age-typical visual [36] and hearing [37] impairments. Since she is limited in her motor-abilities, Jane can only walk with a walker. Steps, uneven paths, and longer distances are barriers for her. Therefore, she tries to organize her everyday life as best as possible around her place of residence. Grocery shopping is only possible with the help of the walker. For visiting more distant places, such as a doctor's office or relatives and friends, Jane is dependent on a family member who is able and willing to drive her. As with most elderly people [31], the lack of opportunities to get around is a noticeable decrease in her perceived quality of life. The organization of everyday life is also becoming increasingly difficult due to a decline of everyday cognitive competencies, which is typical for elderly [38]. For example, navigation in unknown places is more difficult than for younger people. In addition, she cannot use a smartphone for support in unknown places, because she is not used to mobile devices like many elderly people [39]. Furthermore, the use of devices that are operated with a touchscreen is made more complicated due to tremor [40].

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6 First Results

Several design decisions that were made in the development of the prototype in the course of the project UNICAR*agil* are based on the examination of hypothetical future practice scenarios with the described personas as protagonists. It was thus possible to discuss ideas rapidly with several developers and to find technical solutions for the individual challenges associated with the properties of the intended users.

Fig. 4 Test setup for investigating the arrangement of a central control unit in the vehicle’s interior.

When searching for solutions to implement requirements, it was often possible to fall back on already existing concepts. An example is the intended user interface in the vehicle’s interior, which is conceptually planned as a multimodal system as proposed in [41]. Nonetheless, we had to create several new technical solutions in order to fulfil requirements resulting from the novel use of the vehicle by a minor or motor-impaired elderly person without an accompanying person. The features of the vehicle caused by the special needs of the assumed users were a major part of our considerations. This mainly concerns procedures, control elements, usage rights, monitoring functions, and safety requirements. Some examples of the results are given below.

With the help of concrete scenarios, we developed a basic – land somehow unconventional – interior package. For instance, the arrangement of the seats, which provides adequate freedom of movement in the entrance area of the vehicle to enable an entry and exit with an automated entry aid, was defined using concrete entry scenarios that included the stowing of a wide variety of items. An investigation with the help of an interior mock-up confirmed the practicability of the intended solutions.

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As already mentioned, we were able to discuss and further develop the procedures that go along with the use of the vehicle introducing concrete future practice scenarios. An illustrative example is the boarding of passengers which differs depending on the user. First distinctions are already apparent when the vehicle selects a place for entry. In case of the minor Johnny, it is required that the autonomous family vehicle stops on the side of the road where he is located. In case of the elderly Jane, the vehicle needs to select a place for entry that is accessible for her and suitable to provide an automated entry aid. By contrast, no special requirements beyond traffic regulations for the place for entry are formulated when John wants to enter the vehicle. Only in case of the motor-impaired Jane, an automated entry aid is offered as depicted in Fig. 5. Moreover, only in the case of Johnny, an interior monitoring system checks if the expected passengers are sitting in their seats with their seat belts fastened and if there are no objects in areas not designated for this purpose before departure.

Fig. 5 Description of Jane Doe's entry using a digital human and vehicle model (The digital vehicle model used for these investigations was developed by our project partners in the course of the UNICAR*agil* project.)

Furthermore, possible ways of ensuring safe operation of the vehicle were identified. For example, fallbacks were designed for different processes in the considered scenarios. In some cases, these fallbacks were already present due to the design of the vehicle for different users. For example, the design of the vehicle for a person who is not a smartphone user offers a direct fallback level for users who would like to operate the vehicle with their smartphones, which, however, might not be available under certain circumstances. If redundancy was technically not feasible, we required an adequate level of functional safety for the affected components. This concerns, for instance, the automated entry aid: a failure can lead to a motor-impaired person being trapped in the vehicle. In case of conventional vehicles, such risks are reduced by the presence of an accompanying person.

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Fig. 6 Draft of a smartphone interface for configuring the vehicle for the use by individual family members (Lampe, Henrik, 2020. User interface design. Developed in the context of an employment as a student assistant. Source for profile picture: thispersondoesnotexist.com.)

Moreover, conflicting goals became apparent in the development of a vehicle for such diverse users. In [42] is presented how we use a value-oriented reference process to uncover conflicts of user interests. Within the design process it was possible to derive various operating modes from hypothetical scenarios which solved a number of trade-offs. These operating modes are decisive for the vehicle's behavior, the activation of monitoring functions, the provided degree of automation, and the rights of use.

During our considerations it became clear that a reconfiguration of the vehicle for individual users is needed. The intended reconfiguration is based on a user profile, which can be managed by a legal guardian or a caregiver, whom we assumed in every user group. Fig. 6 shows an excerpt from the prototype user interface that can be used to configure the vehicle's supporting functions by the administrator John Doe. By means of the definition of displayed options, their naming and descriptions, we tried to make transparent and understandable what kind of support administrators can activate and how they can configure the vehicle for the independent use by their relatives.

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7 Discussion and Outlook

Despite a number of problems and conflicts that we could solve, we are still far away from being able to find satisfactory solutions for all the difficulties we discovered when considering future practice scenarios. For example, the greatest demands on the geometrical design of the vehicle are made by a motor-impaired user. The spaces that have to be kept free for this person offer no equivalent value to other family members in the scenarios considered so far. Adaptivity of the interior package or a new utilization of the available free space could only be achieved to a limited extent in our case. In case of the elderly user, the selection of the place of entry by the vehicle can lead to significant problems under certain circumstances. For example, the person might be unable to find the vehicle in an unknown or crowded place or the designated place might not be accessible for the person. The resulting requirements directly affect the automation of the vehicle's driving function. Moreover, it remains challenging what happens when the person falls down during boarding. In case of the minor, it occurs to be a major challenge to avoid abuse of the vehicle. For example, it is possible to cheat a mechanism for ensuring that the seat is occupied by the minor with seat belt fastened during the ride. For those scenarios in which the vehicle's capabilities are no longer sufficient, we, as vehicle developers, considered the option of letting the vehicle call a human assistant.

When looking at concrete scenarios, it becomes apparent how far-reaching the requirements are that result from the assumptions about the potential users of the autonomous family vehicle. These requirements do not only relate to those areas of the vehicle that are directly related to the passenger interface. An example is the vehicle's environment perception, which must be able to recognize suitable places for a barrier-free entry. For the development of a driverless vehicle that can be used without human assistance by persons with the restrictions assumed here – or even with further restrictions – new requirements must be considered in the development process. With the help of the scenarios, these requirements can be traced back the assumptions on potential users.

Actually, more iterations of the initial future practice scenarios and a refinement of implementations for the regular use of the vehicle are pending. According to the scenario-based design method presented in [23], a subsequent step will be to create more detailed interaction scenarios based on future practice scenarios and possible problem scenarios, which already appeared to some extent. At the same time, a more detailed description of further future practice scenarios and possible problem scenarios is needed. This includes simple situations such as scheduling conflicts between users who want to use the vehicle at the same time or combined situations with multiple user types in the vehicle. Inappropriate solutions in this area may result in low usability and thus low acceptance among the intended users.

There are also safety critical scenarios that were already gathered and still need to be considered. For instance, it remains to be clarified how the vehicle has to react if it cannot continue to drive due to a technical defect—which cannot be discarded—and a child is the only passenger. In addition to the actual cause of a particular problem, such

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as a technical defect or an acute condition of a passenger, the environment of the vehicle can be crucial. For example, in certain emergencies a different reaction of the vehicle might be required on a highway compared to a residential street.

A change of the assumed use case of the vehicle can cause new challenges. The assumption that the vehicle is owned by a family with a responsible decision maker who decides on the use of the car allowed to simplify the concept development so far. However, this simplifying assumption cannot be made in the development of shared mobility vehicles. In this case, it remains to be clarified how possible providers of mobility services decide who is allowed to use their services by themselves.

Besides the further development of the hypothetical users presented above, it is conceivable to sketch out edge users to define the vehicle's range of users within the development process. Since, for instance, age-typical restrictions, such as those caused by dementia, can be very diverse [43], further differentiations are necessary in the assumptions about elderly people. In this context, a validation by experts – such as gerontologists – might become necessary. Further types of users can be included in the generation of new future practice scenarios. A result might be the exclusion of persons with certain characteristics of the independent use of the vehicle.

Within the prototypical realization of our intended concepts, several technical challenges have to be mastered. One example is the required barrier-free access, which stands in contrast to the vehicle's weight, its door-sill height and its aesthetics. In this case, a compromise that affected several parts of the vehicle has already been worked out. We assume that further conflicts resulting from user-requirements need to be solved during the design and construction of the prototype. Furthermore, it is expected that more conceptual weaknesses will be uncovered during investigations with the use of physical prototypes, especially due to the novelty of some solutions.

8 Conclusion

In this paper, we present the development of a novel autonomous family vehicle using a scenario-based design approach. Thereby, the assumptions regarding different types of users were summarized in terms of personas and a simple combination was used to create scenarios that describe the intended use of the planned vehicle by three contrasting users.

An initial set of hypothetical scenarios helped to discuss technical solutions and to uncover conceptual weaknesses of the planned autonomous family vehicle as well as remaining challenges. These challenges are largely related to the particular characteristics of the representatives of different generations as depicted in this paper. It becomes apparent that the vehicle's design is strongly influenced by the assumptions that are made about the user's restrictions on abilities or on permissions. The consideration of people who are unable to use a conventional car without human support as independent users of an autonomous vehicle causes changes in different areas of the vehicle. The resulting challenges for the development of an autonomous family vehicle

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that is supposed to be a sound product require the cooperation of experts from different disciplines. The general advantages of a scenario-based approach become particularly evident due to the novelty of the considered vehicle concept, which involves several scenarios that previously did not occur within the use of a vehicle. Above all, the design and consideration of concrete usage scenarios uncovers the amount of research and development work that still needs to be done for certain groups of people to become independent users of a driverless vehicle.

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